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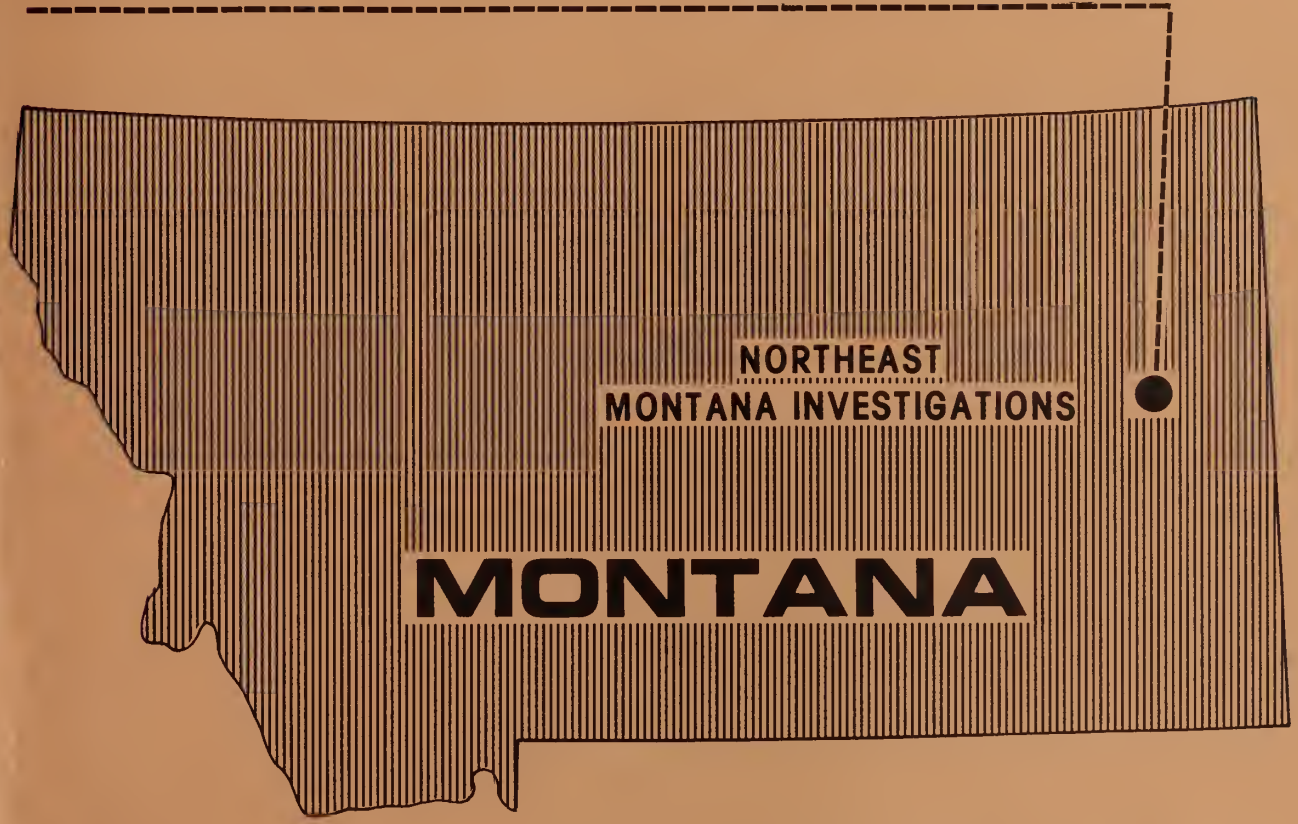
# SUMMARY

## Northeast Montana Investigations Report




## RESOURCE & POTENTIAL RECLAMATION EVALUATION

Northeast Montana Investigations Report
Published July 1983

The Federal Coal Management Program has been designed as an interagency cooperative effort to meet national energy objectives.

Northeast Montana Investigations Report was prepared through the efforts of the U.S. Department of the Interior, principally the Bureau of Land Management and Bureau of Reclamation. The study effort began in 1981 and was concluded in 1983 with the publication of this report.

The areas described in this report have been tentatively determined to be potential Federal coal development areas. The purpose of the report is to provide information on the areas' reclamation potential, should coal development occur. This report will assist managers in making final Federal coal leasing decisions.

Limited copies of the report are available from:

Bureau of Land Management
Montana State Office
222 N. 32nd Street
Billings, MT 59107

50772-101

| REPORT DOCUMENTATION PAGE | 1. REPORT NO. BLM YA-533-1A0-3 | 2. | 3. Recipient's Accession No. |
|---|---|---|---|

**4. Title and Subtitle**
Resource and Potential Reclamation Evaluation: Northeast Montana Investigations

**5. Report Date**
July 1983

**6.**

**7. Author(s)**
Frank Calcagno, Jr. and Glenn H. Westman, Editors

**8. Performing Organization Rept. No.**

**9. Performing Organization Name and Address**
Bureau of Reclamation
Upper Missouri Regional Office
P.O. Box 2553
Billings, MT 59103

**10. Project/Task/Work Unit No.**

**11. Contract(C) or Grant(G) No.**
(C)
(G)

**12. Sponsoring Organization Name and Address**
Bureau of Land Management
Denver Service Center
DFC, Building 50, D-470
Denver, CO 80225

**13. Type of Report & Period Covered**
Final; 81-83

**14.**

**15. Supplementary Notes**
Prepared jointly by the Bureau of Land Management and Bureau of Reclamation

**16. Abstract** The purpose of this investigation was to collect baseline information for establishing reclamation objectives and lease stipulations. The Investigations area, located in northeastern Montana, lies on the border of the glaciated and unglaciated portion of the Great Plains Physiographic Province. The area generally consists of extensive uplands to the southeast of the Missouri-Yellowstone drainage divide and gently rolling topography with isolated buttes to the northwest. Climatic conditions are characterized by cold winters, warm summers, and large variations in seasonal precipitation. Average annual precipitation is about 13 inches; the frost-free season ranges from 110 to 130 days. Bedrock exposed in the area consists predominantly of the Tongue River Member and also the Lebo Shale Member of the Paleocene Fort Union Formation. Miocene to Holocene gravel terraces, Pleistocene glacial deposits, and Holocene alluvial deposits locally mantle the bedrock in the area. Six continuous lignite beds are present in the area, of which four are fairly thick. These beds are the S-, L-, R-, Second Pust Bench, Pust, and Peuse. Soils developing in old or recent alluvium in the area should provide 18 to 36 inches or more of good quality topsoiling material for revegetation. Only 6 to 12 inches of suitable topsoil will be available from the soils forming in residual sandstone, siltstone, shale, or baked rock. Available subsurface materials appear fair to poor in quality. Overburden samples from 9 USBR drill holes were evaluated for use as a supplemental plant medium for revegetation; the physical and chemical charteristics of these materials were highly variable. Twenty-six soil/overburden materials were stratified in the greenhouse as to their comparative revegetation potential.

**17. Document Analysis** a. Descriptors
0510 Environmental Surveys
0807 Coal Deposits
1407 Reclamation

b. Identifiers/Open-Ended Terms
Northeastern Montana, surface-mined land, reclamation, climate, physiography, geology, soils, overburden

c. COSATI Field/Group

| 18. Availability Statement | 19. Security Class (This Report) | 21. No. of Pages |
|---|---|---|
| Release unlimited<br>NTIS<br>Springfield, VA 22161 | Unclassified | |
| | 20. Security Class (This Page) Unclassified | 22. Price |

(See ANSI-Z39.18) See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

# 1244381
TD 195 .S75 E47 no.38-4 Summ c.3

RESOURCE AND POTENTIAL RECLAMATION EVALUATION
OF
NORTHEAST MONTANA INVESTIGATIONS
DAWSON AND MC CONE COUNTIES, MONTANA

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## INTRODUCTION

Recent energy shortages have forced our society to seek new domestic energy sources. Attention has focused on the immense quantities of low sulfur coal that lie within the Rocky Mountain and Northern Great Plains regions. It is the responsibility of the Department of the Interior, principally the Bureau of Land Management, to assist in meeting these energy demands and, at the same time, provide sound reclamation guidelines so that the disturbed lands are restored to an acceptable condition.

## PURPOSE

The purpose of this report is to provide baseline information for establishing reclamation objectives and lease requirements. Detailed data is given on geology, soil and overburden, and greenhouse investigations. Background information on climate and physiography is also provided.

## LOCATION

The five study areas included within the Northeast Montana Investigations are located between the Yellowstone and Missouri Rivers in Dawson and McCone Counties. These include the Circle 2, Upper Thirteenmile Creek, Woodson PRLA, Burns Creek, and Southwest Glendive Study Areas. Plate 1 shows the general location of the five study areas.

The Circle 2 Study Area is adjacent and northeast of Circle, Montana. It includes all of T. 20 N., R. 49 E.; section 36 of T. 21 N., R. 48 E.; sections 20 through 29 and 31 through 36 of T. 21 N., R. 49 E.; sections 1 through 3, 10 through 15, 22 through 27, and 34 through 36 of T. 20 N., R. 48 E.; sections 1 through 3 and 12 of T. 19 N., R. 48 E.; and sections 1 through 12 of T. 19 N., R. 49 E., as shown on Plates 2 and 3.

The Upper Thirteenmile Creek Study Area lies 4 miles north of Bloomfield, Montana. It includes the east half of sections 26 and 35, and sections 25 and 36 of T. 21 N., R. 52 E.; sections 28 through 34 of T. 21 N., R. 53 E.; sections 12, 13, and 24 of T. 20 N., R. 52 N.; and sections 1 through 12, 14 through 22, 29, 30, and 32 of T. 20 N., R. 53 N., as shown on Plate 4.

The Burns Creek Study Area is located 17 miles north of Glendive, Montana. The study area includes sections 22, 25 through 28, and 32 through 36 of T. 20 N., R. 55 E.; sections 1 through 16, and 22 through 24 of T. 19 N., R. 55 E.; and sections 5 through 8, 17 through 21, 28 through 30, and 32 of T. 19 N., R. 56 E., as shown on Plate 5.

The Woodson PRLA Study Area is the smallest of the five sites, and is located approximately 28 miles northeast of Glendive, Montana. The study area consists of sections 30 through 32 of T. 21 N., R. 56 E., and sections 2 through 4, 10, 11, and 14 of T. 20 N., R. 56 E., as shown on Plate 6.

The fifth study area is the Southwest Glendive Study Area, which is located about 6 miles west of Glendive, Montana. This study area consists of sections 23 through 26, 35, and 36 of T. 16 N., R. 53 E.; sections 30 through 32 of T. 16 N., R. 54 E.; sections 1, 2, 10 through 15, and 22 through 27 of T. 15 N., R. 53 E.; and sections 5 through 8, 17 through 20, and 28 through 33 of T. 15 N., R. 54 E., as shown on Plate 7.

The majority of surface ownership in the five study areas is private, with the remainder consisting of State and Federal lands as shown on Plates 8 through 13. Approximately one half of the coal in the study areas is Federally owned; also shown on Plates 8 through 13.

## PRESENT LAND USES

Lands in the Northeast Montana Investigations study areas are presently used for livestock grazing (range) and dryland farming (small grains). Portions of the study areas, particularly the woody draws, provide valuable wildlife habitat.

## POSTMINING LAND USES

Postmining land uses are anticipated to be the same as the present uses, livestock grazing (rangeland), dryland farming (cropland), and wildlife habitat.

## RULES GOVERNING MINING AND RECLAMATION OPERATIONS

In Montana, coal mine operators must comply with all established rules pursuant to the Montana Strip and Underground Mine Reclamation Act (1973). These rules are presented in Appendix A of the "Montana Permanent Program" for regulating surface and underground mining activities.

The Montana Department of State Lands is the regulatory agency responsible for administering this program.

## OBJECTIVE OF RECLAMATION

Montana law presently requires the coal mine operator to restore all disturbed areas, "in a timely manner, either to conditions capable of supporting the uses they were capable of supporting before any mining or to conditions capable of supporting approved alternative land uses. Alternative land uses may be approved by the Department of State Lands after consultation with the landowner or the land-management agency having jurisdiction over the lands . . ." (Rule XVI, 5(c) pursuant to "The Montana Strip and Underground Mine Reclamation Act" - Montana Permanent Program).

Unless an alternative postmining land use is desired by the landowner(s) and approved by the Montana Department of State Lands, the main objective of reclamation in the Northeast Montana Investigation study areas would be to establish a diverse vegetative cover with an interspersion of vegetative types over the reclaimed land capable of supporting livestock and wildlife. The integrity of the visual resource should be maintained.

## CLIMATE

The study areas described in this report have a continental-type semiarid climate characterized by cold winters, warm summers, and large variations in seasonal precipitation.

Data from two weather stations in Dawson County were used to evaluate precipitation. Glendive, at elevtion 2076 feet, receives 12.6 inches of precipitation in average years. Richey, at elevation 2476 feet, records 13.4 inches of average annual precipitation. About 80 percent of the annual precipitation normally occurs during the growing season, April through September. June is commonly the wettest month.

Most summer precipitation occurs in showers. Thunderstorms, most common in July and August, occasionally produce hail heavy enough to damage crops.

Snowfall usually averages about 28 inches in the Yellowstone Valley and slightly more in the uplands. Heavy snowfalls, though uncommon, may occur infrequently in late winter or early spring.

Based on temperature data recorded at Glendive and Richey, January is usually the coldest month in this area, with an average daily maximum temperature of approximately 24° F. and an average daily minimum temperature of about 2° F. July is typically the warmest month, with an average daily maximum temperature of about 87° F. and an average daily minimum temperature of about 57° F.

The frost-free period (>32° F.), lasting from early May through late September, ranges from about 110 days in the uplands to more than 130 days in the Yellowstone Valley. The growing season for hardy crops (>28° F.) ranges from about 120 days in the uplands to as much as 150 days in the Yellowstone Valley. Growth of native range plants and small grains is rapid during May and June. By about mid-July, however, the available soil moisture is usually depleted and the plants mature or become dormant.

Climate will be a controlling factor for revegetation in the Northeast Montana Investigations study areas. In most years, the spring rains, coupled with stored soil moisture from winter precipitation, will provide adequate moisture for establishing good stands of native range vegetation, small grains, or other adapted crops.

Specific climatic factors that could adversely affect revegetation include: (1) below normal or uneven distribution of precipitation, especially during the growing season, (2) intense thunderstorms or hailstorms that damage vegetation and/or cause soil erosion, (3) late spring freezes, and (4) depletion of soil moisture by wind. Additonal on-site data collection will be necessary prior to mining to more accurately determine probabilities of occurrence of these factors. This data can then be used to select best possible seeding times for revegetation.

## PHYSIOGRAPHY

With one exception, the five study areas comprising the Northeast Montana Investigations are situated in the unglaciated portion of the Great Plains Physiographic Province. The northern portion of the Circle 2 Study Area, however, lies within the glaciated portion of this Physiographic Province.

Two distinct types of topography present in the area are separated by the Missouri-Yellowstone River drainage divide, which trends northeastward across the center of the Investigations area. Southeast of the divide are extensive upland areas consisting of a series of terraces, one-half to 3 miles wide, which

extend for many miles along the Yellowstone River. These terrace levels range from 15 to more than 1,000 feet above the river. The higher terraces are undulating and are dissected by streams. The lower terraces are broad, with less dissection. The topography northwest of the divide is predominantly rolling; however, it often displays varied features such as isolated buttes, small mesas, and benches. Overall, a rugged topography is formed by differential erosion which, in many cases, forms "badlands" and cliffs.

The major valleys in the area are wide and open, with broad alluvial flats trenched by stream channels up to 30 feet deep. The alluvial flats are usually bordered by low bluffs and "badlands." Further to the north, the "badlands" develop into the "breaks" of the Missouri River.

The maximum relief in the Investigations area is about 1,467 feet, with elevations ranging from approximately 2000 feet to about 3467 feet. Local relief, however, seldom exceeds 300 feet.

All of the area located southeast of the Missouri-Yellowstone River divide drains into the Yellowstone River, while the area northwest of the divide drains into the Missouri River. The tributary streams of the Missouri and Yellowstone Rivers become intermittent during summer and fall. Although the flow of these streams appears small, it is probable that a considerable amount of water migrates downstream in the alluvial sand and gravel beneath the surface.

## GEOLOGY

The five study areas within the Northeast Montana Investigations are located on the west edge of the Williston Basin in northeastern Montana. This basin is a synclinal structure with a general northwest-southeast trend extending from South Dakota into Canada, a distance of about 500 miles.

Bedrock exposed in the study areas consists mainly of the Paleocene Tongue River Member of the Fort Union Formation; however, the eastern portion of the Southwest Glendive Study Area also consists of the Lebo Shale Member of the Fort Union. Overlying the bedrock in the area are unconsolidated gravel terrace deposits ranging from Miocene through Holocene age, Pleistocene glacial till and proglacial lacustrine deposits, and Holocene alluvial deposits.

Approximately 15 lignite beds greater than 0.4 foot thick were penetrated by drilling in the study areas. Of these, six continuous beds are present, four of which are fairly thick. The six beds are the S-, L-, R-, Second Pust Bench, Pust, and Peuse beds.

Engineering property tests performed on bedrock materials similar to those in the Northeast Montana Investigations revealed that shear strengths are low. Slides can develop adjacent to high walls in surface mines, and saturated alluvial deposits and uncemented siltstones and fine-grained sandstones will readily erode and flow into excavations.

Excavation slopes will vary between minesites and will be dependent on exposure time, moisture conditions, material types, and depth of cut.

After disturbance, an increase of about 25 percent will occur in the volume of the overburden. Some areas of the surface will actually be higher in elevation

after mining. Settlement will then occur for several years after reclamation until the materials reach a stable condition.

Three types of instability are common on reclaimed coal-mined areas in the Northern Great Plains. They are: (1) areawide settling, (2) localized collapse, and (3) piping. Each form of instability is affected by certain variables in the postmining landscape. These variables include the physical and chemical characteristics of the overburden, the method and equipment used in stripping and contouring operations, and the season when these activities occur. One or more of these types of landscape instabilities may occur on reclaimed land in the Northeast Montana Investigations.

Weathering tests were not conducted on samples from the Northeast Montana Investigations; however, results from the Otter Creek Study Site indicated that freezing-thawing caused more weathering or breakdown than wetting-drying. The study also indicated that the materials weather at different rates, which will require various methods of handling, storing, and processing.

A study of the seismic history of the region indicates that minor damage could result to structures from earthquake shocks.

No significant paleontological finds were observed in the study area.

## SOIL AND OVERBURDEN

Representative sections within the Southwest Glendive, Upper Thirteenmile Creek, and Woodson PRLA Study Areas were classified by the Bureau of Reclamation as to their suitability for reclamation and revegetation. Two other study areas described in this report, Burns Creek and Circle 2, were not classified.

Three major soil categories are common to the Southwest Glendive, Upper Thirteenmile Creek, and Woodson PRLA Study Areas. These are: (1) soils developing in old alluvium on ancient terraces of the Yellowstone River, (2) soils forming in recent alluvium on fans and footslopes and in swales and drainage bottoms, and (3) soils developing in residual sandstone, siltstone, shale, or baked rock (scoria) on ridges and sideslopes.

Representative sections 14 and 22, T. 15 N., R. 53 E., were classified by the USBR in the Southwest Glendive Study Area. Soils developing in old alluvium cover almost all of section 14, as well as a small portion in the northeast corner of section 22. These soils occur on a nearly level to undulating high terrace (Pleasant View Flat) of the ancient Yellowstone River. Soils developing in recent alluvium occur on about 50 percent of section 22 and a small portion in the northeast corner of section 14. These soils occupy nearly level to moderately sloping fans, footslopes, swales, and narrow drainage bottoms. The soils developing in residual sandstone, siltstone, or shale occupy ridges and moderate to very steep sideslopes on the remaining 50 percent of section 22. The sedimentary beds belong to the Tongue River Member of the Fort Union Formation.

The east half of section 6 and all of section 8, T. 20 N., R. 53 E., were selected as representative for land classification by the USBR in the Upper Thirteenmile Creek Study Area. Soils developing in residual sandstone, siltstone, shale, or baked rock (Tongue River Member, Fort Union Formation) occur on about 55 percent of section 6 (E1/2) and approximately 30 percent of section 8. These soils occupy ridges and moderate to very steep sideslopes. Soils

forming in old alluvium cover about 35 percent of section 8 (northern portion) and a small piece near the east quarter corner of section 6 (E1/2). These soils occupy an undulating high terrace and strongly sloping terrace edge. Soils developing in recent alluvium occur on about 45 percent of section 6 (E1/2) and 35 percent of section 8. These soils have developed in stream-laid deposits or local wash on gently to moderately sloping fans, footslopes, swales, and drainage bottoms.

Section 4, T. 20 N., R. 56 E., was selected for land classification by the USBR in the Woodson PRLA Study Area. Soils developing in recent alluvium cover about 55 percent of this section. They occur on dissected alluvial fans and in the bottom of deeply-incised drainages. Soils forming in residual shale, siltstone, sandstone, or baked rock (scoria) occur on about 40 percent of section 4. They occupy ridges and moderate to very steep sideslopes. The parent strata of these soils belong to the Tongue River Member, Fort Union Formation. Soils forming in old alluvium occur on about 5 percent of this section. They occupy a thin, gently sloping high terrace (Butler Table) of the ancient Yellowstone River and a steeply sloping terrace edge (southwest part of section).

A semidetailed land suitability classification was made of representative sections in the Southwest Glendive, Upper Thirteenmile Creek, and Woodson PRLA Study Areas in order to evaluate and characterize the soil and overburden to 10 feet in depth as a source of material for revegetation if surface mining occurs. This classification provides data on the quantity and quality of material available for revegetation, as well as the ease with which this material can be stripped and stockpiled.

Land suitability specifications, shown on Table 1, were developed to establish classes for the specific use proposed, i.e., as a source of material for revegetation of surface-mined lands. Four land classes: 1, 2, 3, and 6 were developed. These correspond to classes used in the Bureau of Reclamation land classification system.

Class 1 lands provide the most desirable and plentiful source of material for revegetation. An abundant supply of highly suitable material, which is easily stripped and stockpiled, will be available from this land class. In addition to having an adequate amount of suitable material for reclaiming the immediate area, Class 1 lands can provide borrow material for topdressing areas with insufficient suitable material. Class 2 lands contain an adequate supply of resurfacing material to revegetate the immediate area; however, this material is slightly less desirable in quality or somewhat more difficult to strip and stockpile than the material on Class 1 lands. Class 3 lands are similar to those in Class 2, except the deficiencies are more pronounced or a combination of deficiencies exists. Land in this class is marginally suitable for revegetation but, through utilization of good stripping and stockpiling procedures, the requirements for planting media can generally be met. Class 6 lands lack adequate quantities of suitable material to meet the needs for revegetation. If these lands are disturbed by surface mining, it will be necessary to borrow material from Class 1 or 2 lands or modify the material available for revegetation through leaching, addition of chemical amendments, etc.

The results of the land suitability classification expressed as a percentage of each study area are as follows:

Southwest Glendive: Class 1 - 40.2 percent, Class 2 - 35.5 percent, Class 3 - 20.3 percent, Class 6 - 4.0 percent.

Upper Thirteenmile Creek: Class 1 - 38.1 percent, Class 2 - 31.3 percent, Class 3 - 16.8 percent, Class 6 - 13.8 percent.

Woodson PRLA: Class 1 - 2.0 percent, Class 2 - 41.6 percent, Class 3 - 13.2 percent, Class 6 - 43.2 percent.

The soils developing in old alluvium in these study areas represent the most abundant source of revegetative material. About 24 to 36 inches (or more) of good quality topsoil will be available from most of these soils.

The A horizon of these soils, which averages 6 inches in thickness, could be selectively stripped as first lift material, followed by stripping of the good quality B and upper C horizons in the second lift. The lower C horizons consist of sand and gravel deposits, weathered sedimentary beds, or loamy alluvium which, locally, contains moderate levels of soluble salts. Though abundant in quantity, these materials are fair to poor in quality for use as planting media; therefore, they should be placed well below the plant rooting zone in reconstructed profiles.

Stripping operations on the gently sloping to undulating high terraces should be relatively easy.

Soils forming in recent alluvium in the Southwest Glendive and Upper Thirteenmile Creek Study Areas should yield about 18 to 24 inches (or more) of good quality topsoil for revegetation. In the Woodson PRLA Study Area, slightly less (about 12 to 18 inches) topsoiling material is available from these soils.

The topsoiling material generally includes the A and upper C horizons of the soils in the Southwest Glendive and Upper Thirteenmile Creek Study Areas. In addition, some profiles also have a weakly to moderately developed B horizon present. The A horizon (Ap) is commonly 6 to 8 inches thick due to cultivation. This horizon could be selectively stripped as first lift material, followed by stripping of the B and/or C horizons in the second lift.

In the Woodson PRLA Study Area, the topsoiling material is typically comprised of an A horizon 2 to 4 inches thick and a B2 horizon 10 to 16 inches thick. Since the A horizon is thin, selective stripping of this horizon from the B2 appears impractical; however, mixing of these horizons in the first lift should not appreciably alter the overall quality of the material.

The lower C horizons (includes B3 and C horizons in Woodson PRLA) in many of these soils consist of loamy alluvium or weathered sedimentary beds which often contain moderate to high levels of soluble salts. Locally, they are also heavy textured and slightly to moderately sodic. These undesirable properties should limit the placement of these materials to below the root zone (2-3 feet) in reconstructed profiles.

Stripping of suitable material from these soils should be relatively easy on gently to moderately sloping fans and footslopes. Stripping operations in the drainage bottoms may be difficult due to their narrowness and, in some cases, thick tree/brush cover.

The soils developing in residual sandstone, siltstone, shale, or baked rock (scoria) in these study areas represent a limited source of revegetative material. Generally, less than 12 inches of suitable topsoil/subsurface material is available from ridges and moderate sideslopes occupied by these soils. This material usually consists of a thin A horizon (1 to 4 inches) and the upper C horizon(s). Little or no suitable soil material is available on the steep sideslopes and severely eroded ridges.

Some of the underlying weathered sedimentary beds (lower C horizons) are of suitable quality for use as subsurface material immediately below the topsoil. However, many of the beds are heavy textured, moderately to highly saline, and/or moderately sodic. These materials are unsuitable for use as plant media; therefore, they should be selectively placed at least 2 to 3 feet below the surface in reconstructed profiles.

Stripping of suitable topsoil and subsurface material from these soils may be difficult due to slope limitations and landscape complexity, i.e., narrow ridges separated by steep slopes.

Overburden samples from Bureau of Reclamation Drill Holes 81-101 through 81-109 were evaluated as to their suitability for use as a supplemental plant medium for revegetation. These drill holes were located as follows:

81-101 Woodson PRLA Study Area - Sec. 4, T. 20 N., R. 56 E.
81-102 Burns Creek Study Area - Sec. 30, T. 19 N., R. 56 E.
81-103 Burns Creek Study Area - Sec. 24, T. 19 N., R. 55 E.
81-104 Upper Thirteenmile Creek Study Area - Sec. 8, T. 20 N., R. 53 E.
81-105 Upper Thirteenmile Creek Study Area - Sec. 32, T. 21 N., R. 53 E.
81-106 Southwest Glendive Study Area - Sec. 14, T. 15 N., R. 53 E.
81-107 Southwest Glendive Study Area - Sec. 26, T. 15 N., R. 53 E.
81-108 Circle 2 Study Area - Sec. 26, T. 20 N., R. 49 E.
81-109 Circle 2 Study Area - Sec. 4, T. 20 N., R. 49 E.

Complete laboratory analyses, including selected trace element determinations, were performed on the samples by Bureau of Reclamation laboratories in Bismarck, North Dakota, and Boise, Idaho.

The suitability criteria listed in Table 2 were applied to the laboratory data in order to place the overburden materials into one of three categories: Suitable, Limited Suitability, or Unsuitable.

Woodson PRLA Study Area - Drill Hole 81-101

Approximately 19 percent of the overburden materials were rated suitable for use as supplemental plant media, 69 percent were of limited suitability, and 12 percent were unsuitable.

The samples consisted of alluvium (0 to 28 feet) and interbedded sandstone, siltstone, or shale (28 to 131 feet) belonging to the Tongue River Member, Fort Union Formation.

Burns Creek - Drill Holes 81-102 and 81-103

About 48 percent of the samples from drill hole 81-102 were rated suitable, 30 percent were of limited suitability, and 22 percent were unsuitable. In drill hole 81-103, about 19 percent of the samples were classed as suitable, 52 percent were of limited suitability, and 29 percent were unsuitable.

The surface samples (10 to about 35 feet) from both drill holes consisted of alluvium (Flaxville Gravel); below this, the samples consisted of soft sandstone, siltstone, or shale of the Tongue River Member, Fort Union Formation.

Upper Thirteenmile Creek - Drill Holes 81-104 and 81-105

In drill hole 81-104, approximately 37 percent of the overburden materials were classified as suitable for use as supplemental plant media, 37 percent were of limited suitability, and 26 percent were unsuitable. About 54 percent of the samples from drill hole 81-105 were rated suitable and 46 percent were of limited suitability. No samples from this drill hole were determined to be unsuitable.

The samples consisted primarily of soft siltstones, shales, or sandstones belonging to the Tongue River Member of the Fort Union Formation, although the surface sample (10-14 feet) from drill hole 81-105 consisted of alluvium.

Southwest Glendive - Drill Holes 81-106 and 81-107

About 64 percent of the overburden materials from drill hole 81-106 were rated suitable for use as supplemental revegetative media and 36 percent were unsuitable. None of the materials were placed in the limited suitability category. Only three samples were obtained from drill hole 81-107 due to poor core recovery. Of these, two were of limited suitability and one was unsuitable.

Stratified alluvium (Cartwright Gravel) comprised the first 78 and 92.5 feet, respectively, in drill holes 81-106 and 81-107. The suitability of these materials varies with texture, i.e., the silty or fine sandy materials are suitable or of limited suitability for use as supplemental plant media and the coarse sandy and/or gravelly materials are unsuitable. Below the alluvium, silty or sandy shale samples (Tongue River Member, Fort Union Formation) were obtained from above and immediately below the major coal seam.

Circle 2 - Drill Holes 81-108 and 81-109

None of the overburden samples from these two drill holes were rated suitable for use as supplemental plant media. In drill hole 81-108, about 40 percent of the materials were of limited suitability and 60 percent were unsuitable. Approximately 21 percent of the materials in drill hole 81-109 were of limited suitability and 79 percent were unsuitable.

All samples from these drill holes consisted of soft shales, siltstones, or sandstones belonging to the Tongue River Member, Fort Union Formation.

The suitable samples from drill holes 81-101 through 81-109 consisted primarily of soft siltstones, sandy siltstones, silty shales, or loamy alluvium which were medium textured, nonsaline, nonsodic, and free of toxic contaminants (i.e., heavy metals).

The samples which were rated as limited suitability or unsuitable were restricted by several adverse properties including: moderate to high salinity, moderate to high content of exchangeable sodium, coarse or heavy textures, and in a few samples, a moderately high level of nickel or manganese. Under the present alkaline condition of these overburden materials, the availability of these metals to plants is low; therefore, the potential for phytotoxic effects appears minimal.

Overburden materials rated as limited suitability due to moderately fine (or coarse) texture or moderate salinity could be utilized as subsurface material immediately below the topsoil in deficient areas. The unsuitable materials, however, should be selectively placed at least 2 to 3 feet below the plant rooting zone in reconstructed profiles.

## GREENHOUSE EVALUATION OF SOIL AND OVERBURDEN MATERIALS

The data in this section was provided by E&A Environmental Consultants, Inc., Stoughton, Massachusetts, under Bureau of Reclamation Contract Number 1-07-DV-00124.

Twenty-six soil and overburden samples from 5 USBR Point Site Soil Profiles in the Southwest Glendive, Upper Thirteenmile Creek, and Woodson PRLA Study Areas were evaluated in this greenhouse study. Barley Var. Steptoe was chosen as the test species for evaluating the comparative productivities of the various soils and overburden materials. A summary of the findings is as follows:

1. All of the soil/overburden samples were medium or moderately fine textured. A few of the samples contained a high percentage of silt (>80 percent), making them undesirable for surface replacement in reconstructed profiles. These materials would be highly susceptible to wind erosion.

2. Samples from the Southwest Glendive and Upper Thirteenmile Creek Study Areas were nonsaline (A and B horizons) or slightly saline (C horizons). They were all nonsodic. The A and B horizons in the soil profile from the Woodson PRLA Study Area were nonsaline and slightly saline, respectively. The lower C horizons, however, were highly saline and highly sodic. The slightly saline materials, though undesirable as a germination medium (topsoil), could be utilized as subsurface material. The highly saline/sodic materials could severely restrict plant germination and development if they are replaced in the root zone; they should be selectively placed below 2 to 3 feet of nonsaline/nonsodic material wherever possible.

3. Arsenic levels (total analysis) were high in both the preplant and postharvest analysis of the soil and overburden. However, the plant tissue analysis showed low uptake of this element, indicating no apparent phytotoxic effects, at least to this test species (Barley Var. Steptoe).

4. Boron levels (total analysis) were within the normal range for soils in both the preplant and postharvest analysis of the soil and overburden. However, some of the plants contained a relatively high level of this element, possibly in sufficient quantity to reduce productivity.

5. Overall, the correlation coefficients ("R" values) for plant dry weights versus both the preplant and postharvest analyses of the soil and overburden were low, indicating no significant trends. Cadmium (in the plant tissue) had the best correlation with plant dry weight, with an "R" value of 0.472.

Plate I

CIRCLE 2 STUDY AREA

UPPER THIRTEENMILE CREEK STUDY AREA

WOODSON PRLA STUDY AREA

BURNS CREEK STUDY AREA

SOUTHWEST GLENDIVE STUDY AREA

T 21 N
T 20 N
T 19 N
T 18 N
T 17 N
T 16 N
T 15 N

R 48 E
R 49 E
R 50 E
R 51 E
R 52 E
R 54 E
R 55 E
R 56 E

N

2 1 0 1 2 3 4 5 6
SCALE OF MILES

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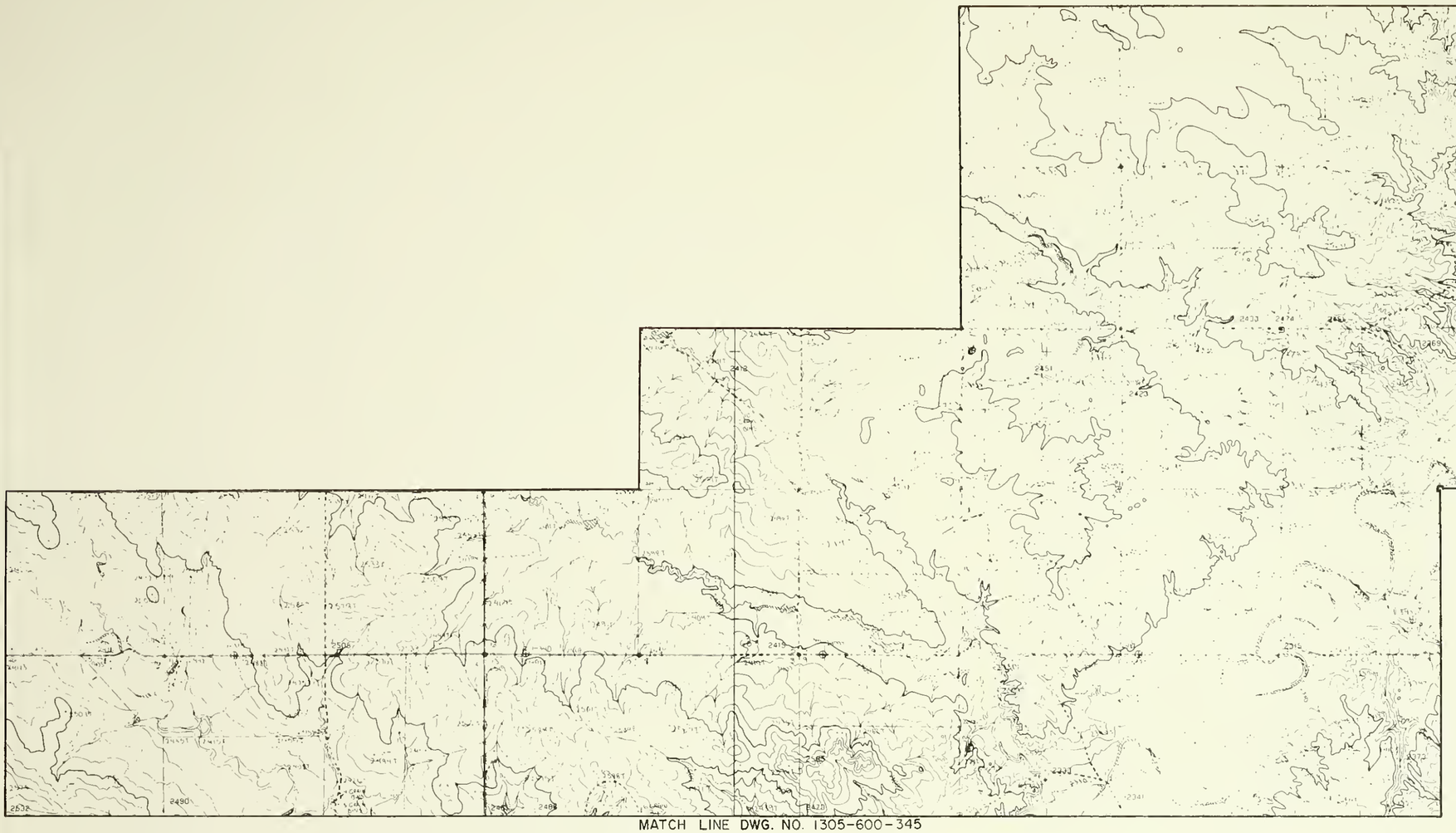
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
RESOURCE AND POTENTIAL RECLAMATION EVALUATION
NORTHEAST MONTANA INVESTIGATIONS

# GENERAL LOCATION MAP

DESIGNED C. BOTOORF FIELD APPROVAL
DRAWN S. STARCEVICH TECHNICAL APPROVAL
CHECKED APPROVED

BILLINGS, MONTANA MAY 1983 1305-600-343



MATCH LINE DWG. NO. 1305-600-345

1 1/2 0 1 MILE

Multiply miles by 1.609 to obtain kilometers.

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NORTHEAST MONTANA INVESTIGATIONS
CIRCLE 2 STUDY AREA

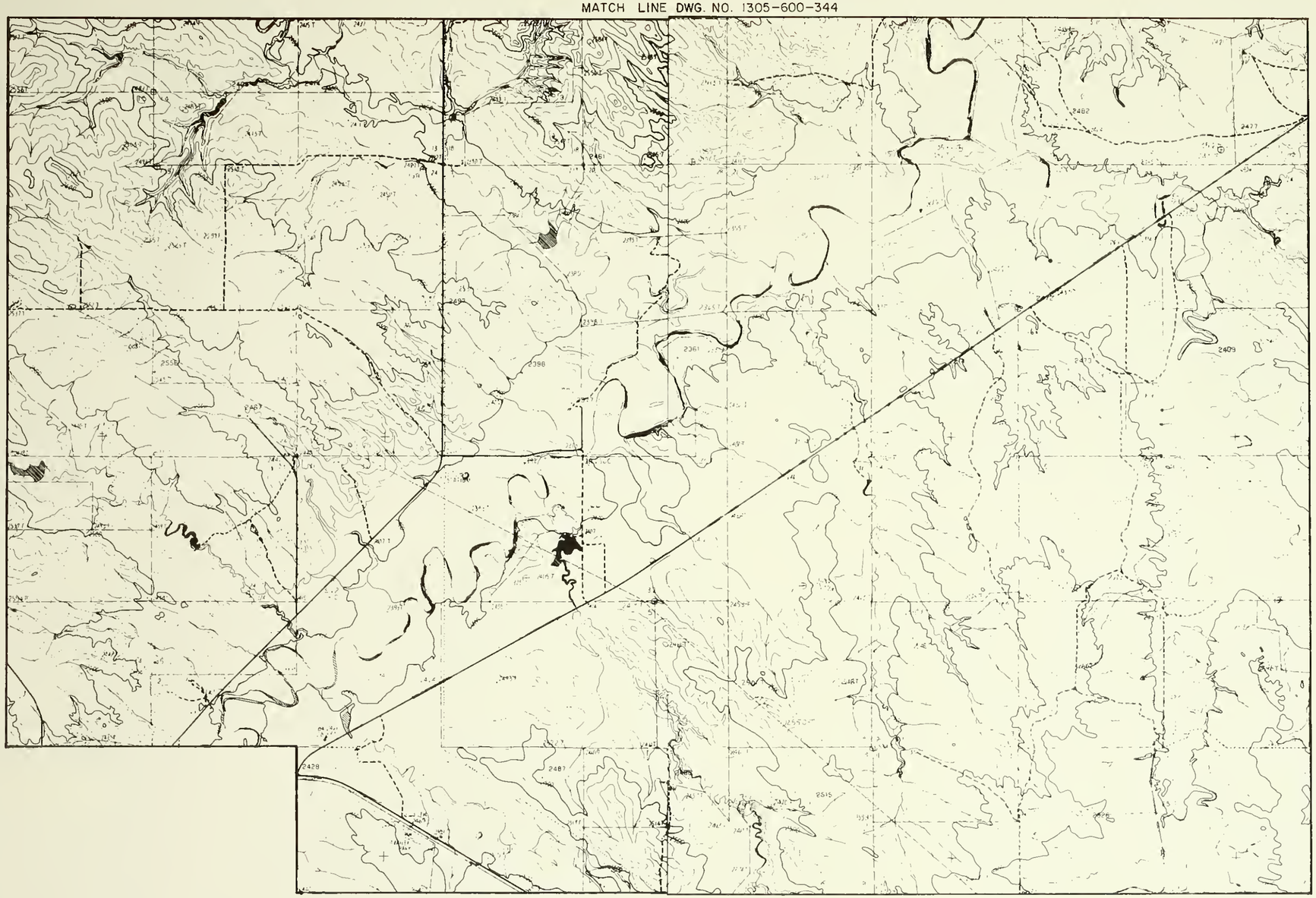
# TOPOGRAPHY

DESIGNED F. CALCAGNO FIELD APPROVAL
DRAWN S. STARCEVICH TECHNICAL APPROVAL
CHECKED APPROVED

BILLINGS, MONTANA MAY 1983
SHEET 1 OF 2

1305-600-344

MATCH LINE DWG. NO. 1305-600-344



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NORTHEAST MONTANA INVESTIGATIONS
CIRCLE 2 STUDY AREA

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BILLINGS, MONTANA MAY 1983
SHEET 2 OF 2

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1/2 0 1 MILE

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RESOURCE AND POTENTIAL RECLAMATION EVALUATION

NORTHEAST MONTANA INVESTIGATIONS
UPPER THIRTEENMILE CREEK STUDY AREA

# TOPOGRAPHY

DRAWN F. CALCAGNO SUBMITTED
TRACED S. STARCEVICH RECOMMENDED
CHECKED APPROVED

BILLINGS, MONTANA MAY 1983 | 1305-600-346

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RESOURCE AND POTENTIAL RECLAMATION EVALUATION

NORTHEAST MONTANA INVESTIGATIONS
BURNS CREEK STUDY AREA

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NORTHEAST MONTANA INVESTIGATIONS
WOODSON PRLA STUDY AREA

# TOPOGRAPHY

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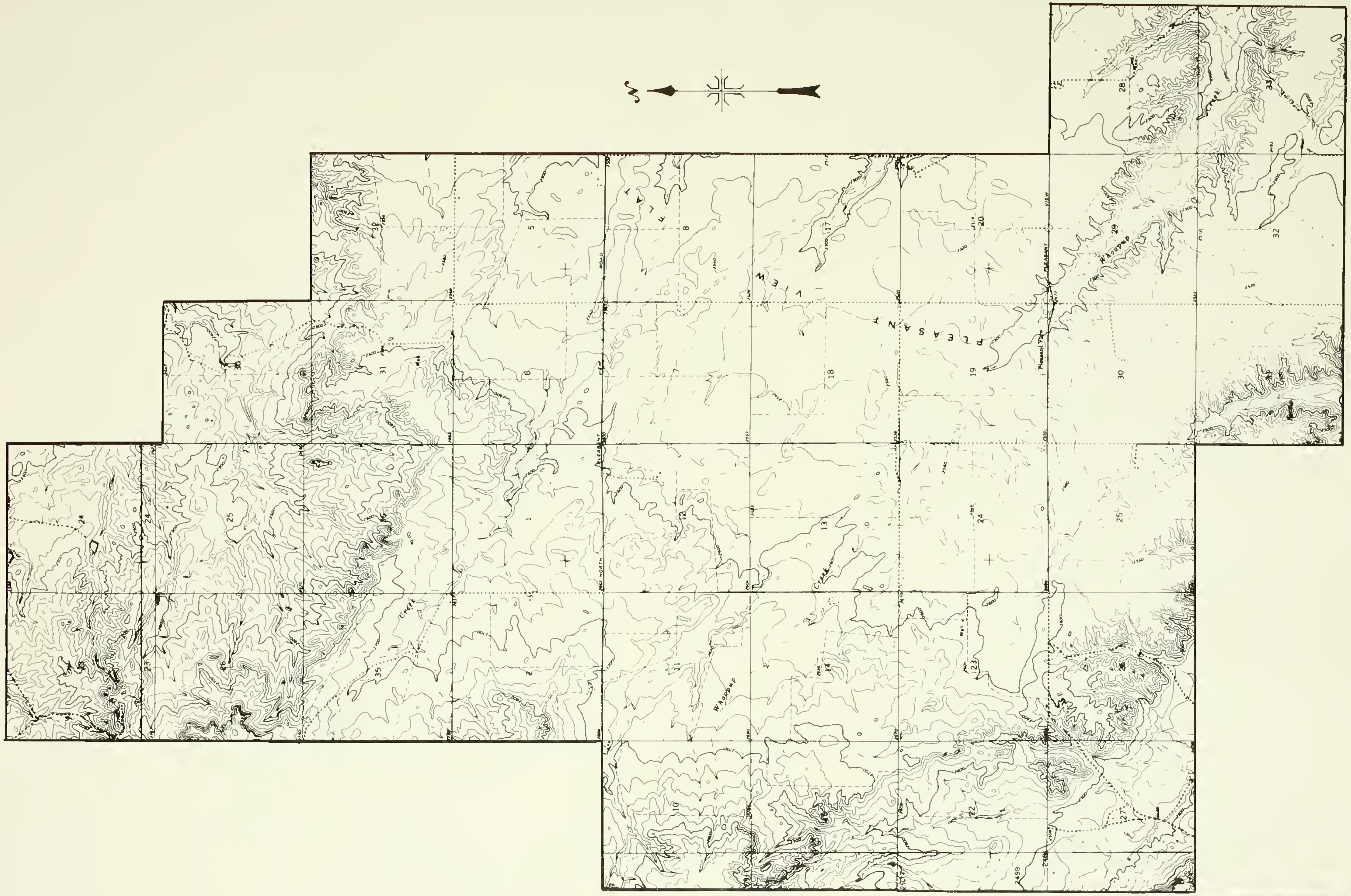
DRAWN S. STARCEVICH TECHNICAL APPROVAL
CHECKED APPROVED

BILLINGS, MONTANA MAY 1983 1305-600-348

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RESOURCE AND POTENTIAL RECLAMATION EVALUATION

NORTHEAST MONTANA INVESTIGATIONS
SOUTHWEST GLENDIVE STUDY AREA

# TOPOGRAPHY

DRAWN F. CALCAGNO SUBMITTED
TRACED S. STARCEVICH RECOMMENDED
CHECKED APPROVED

BILLINGS, MONTANA MAY 1983 1305-600-349

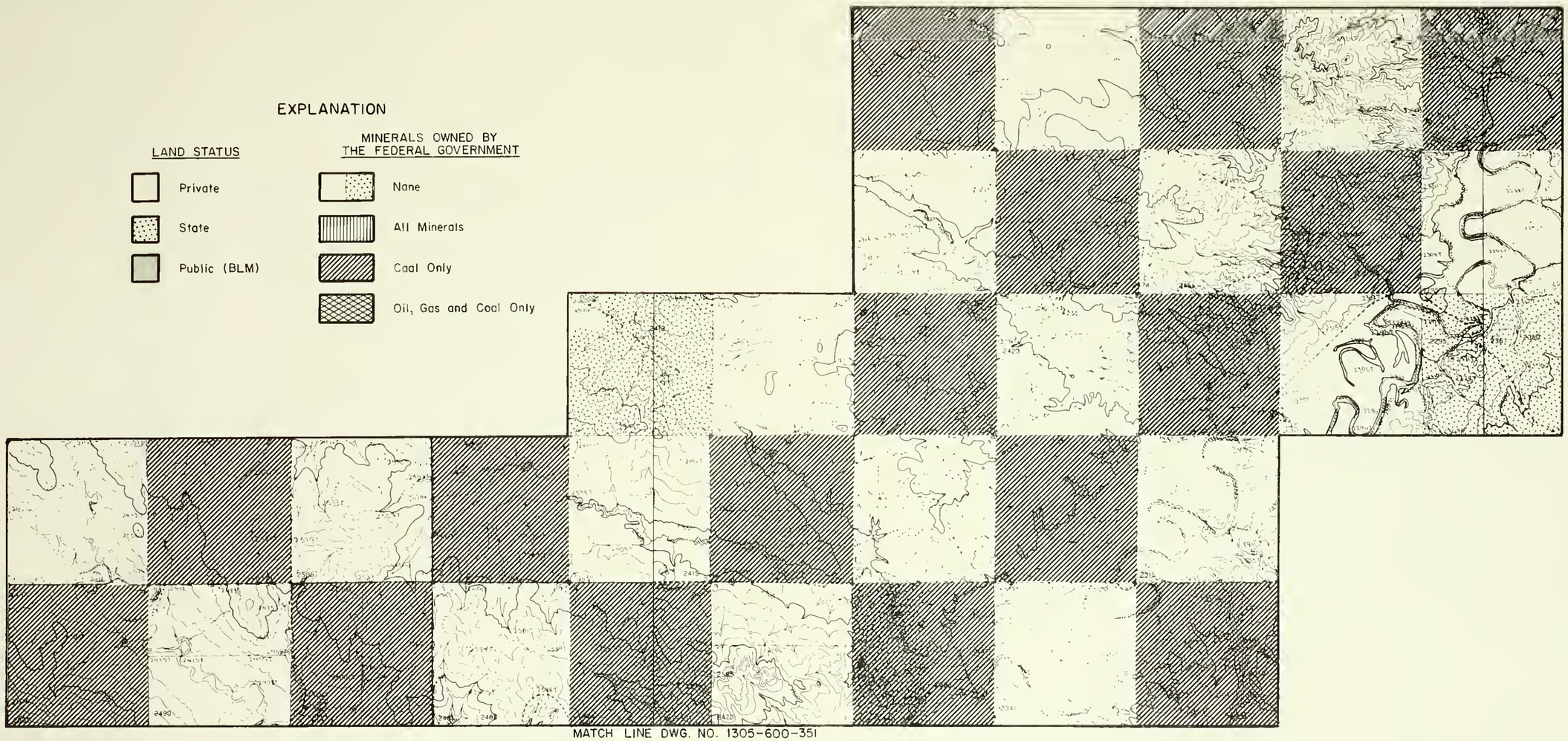
## EXPLANATION

LAND STATUS

- Private
- State
- Public (BLM)

MINERALS OWNED BY THE FEDERAL GOVERNMENT

- None
- All Minerals
- Coal Only
- Oil, Gas and Coal Only



MATCH LINE DWG. NO. 1305-600-351

N

1 1/2 0 1 MILE

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RESOURCE AND POTENTIAL RECLAMATION EVALUATION

NORTHEAST MONTANA INVESTIGATIONS
CIRCLE 2 STUDY AREA

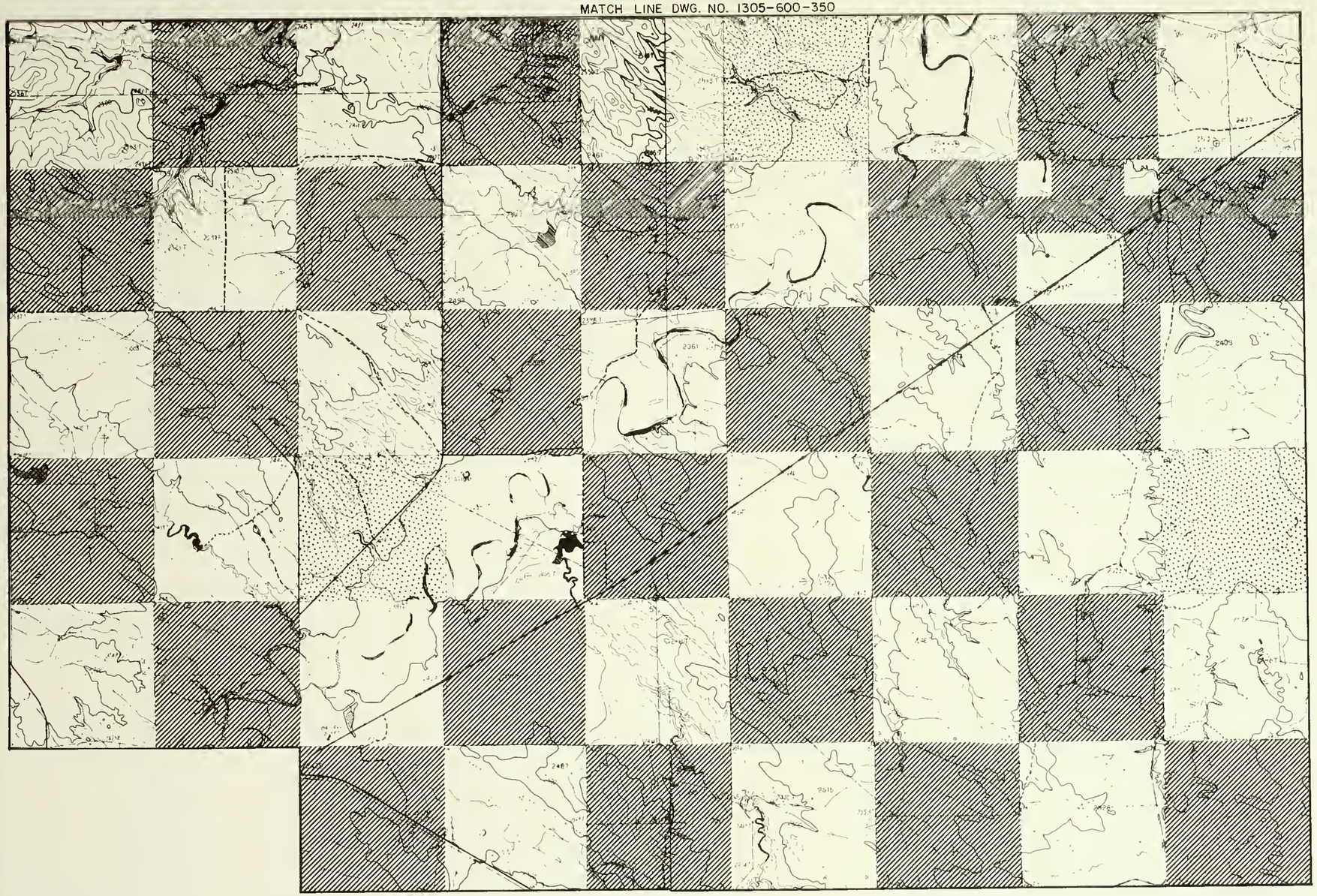
# LAND AND MINERAL STATUS

DESIGNED F. CALCAGNO FIELD APPROVAL
DRAWN S. STARCEVICH TECHNICAL APPROVAL
CHECKED APPROVED

BILLINGS, MONTANA MAY 1983
SHEET 1 OF 2

1305-600-350

MATCH LINE DWG. NO. 1305-600-350



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CIRCLE 2 STUDY AREA

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CHECKED APPROVED

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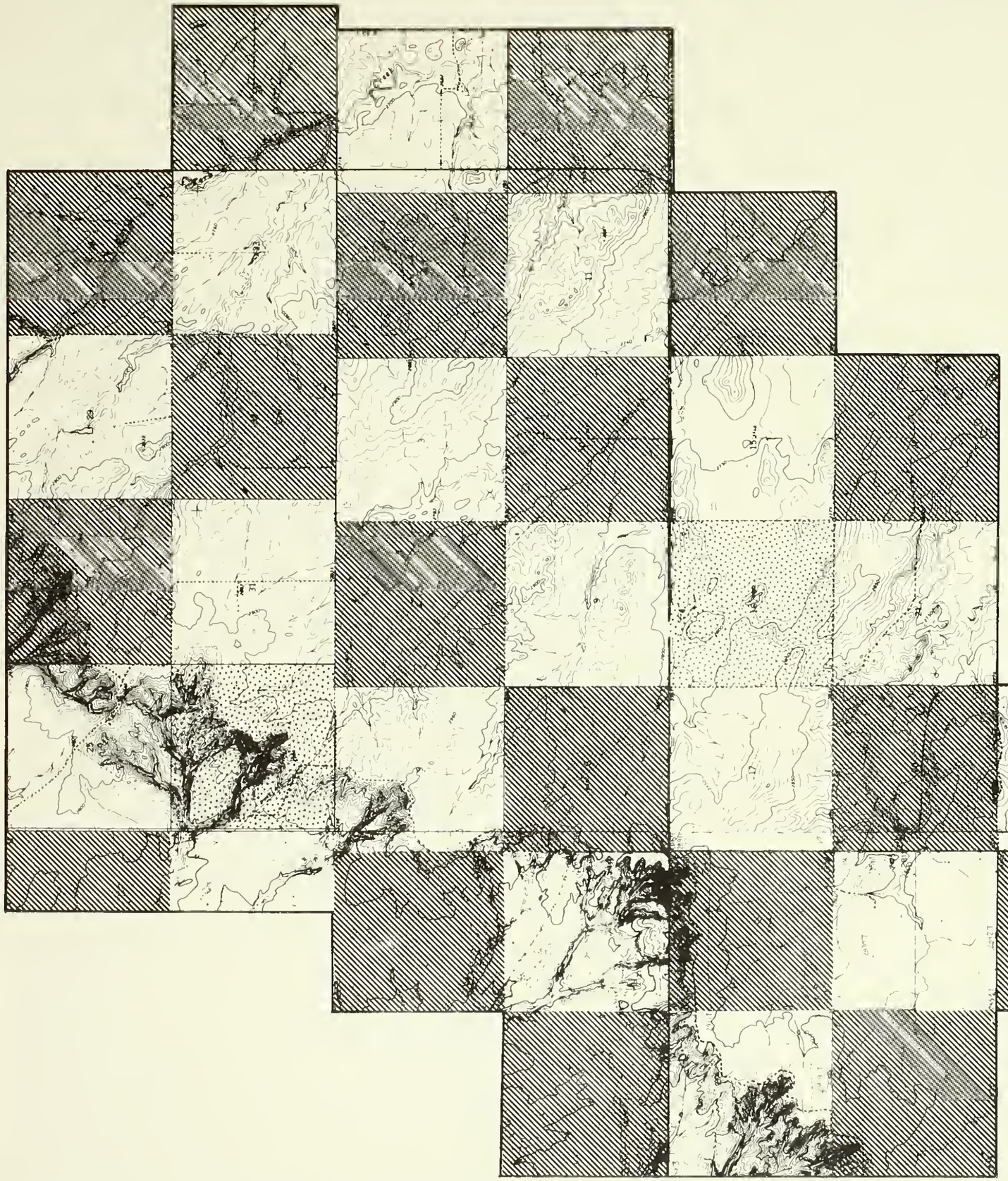
SHEET 2 OF 2

1305-600-351



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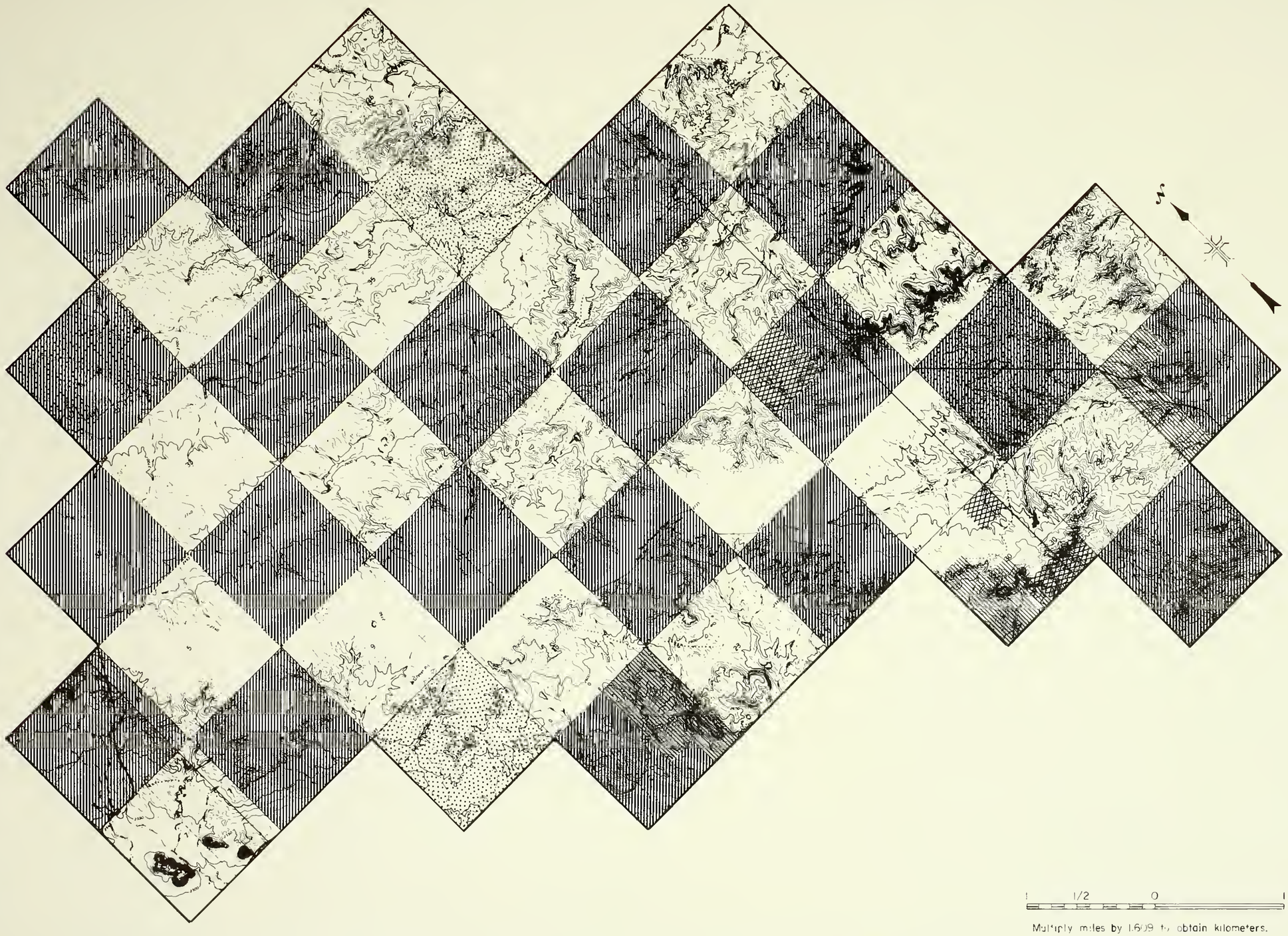
NORTHEAST MONTANA INVESTIGATIONS
UPPER THIRTEENMILE CREEK STUDY AREA

# LAND AND MINERAL STATUS

DRAWN F. CALCAGNO SUBMITTED
TRACED S. STARCEVICH RECOMMENDED
CHECKED APPROVED

BILLINGS, MONTANA MAY 1983 | 1305-600-352



EXPLANATION

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NORTHEAST MONTANA INVESTIGATIONS
BURNS CREEK STUDY AREA

# LAND AND MINERAL STATUS

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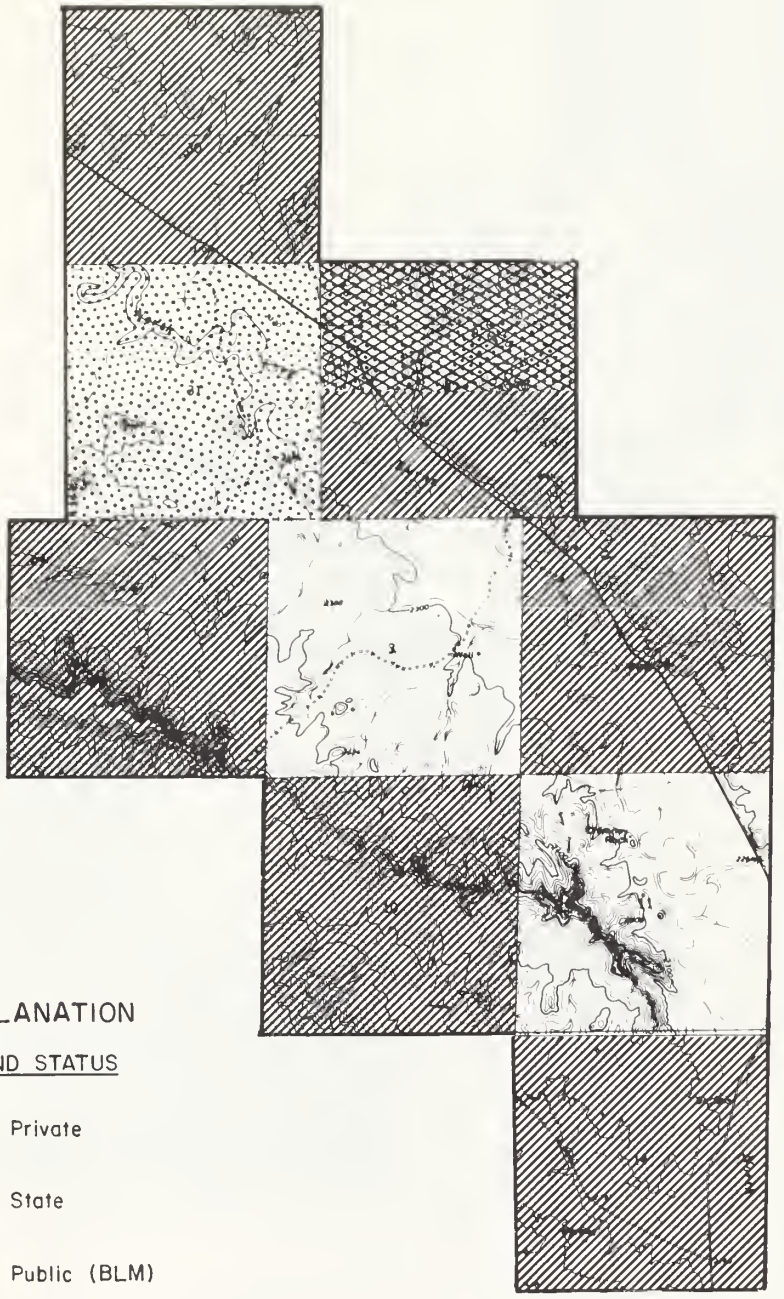
DRAWN S. STARCEVICH TECHNICAL APPROVAL

CHECKED APPROVED

BILLINGS, MONTANA MAY 1983 | 1305-600-353



## EXPLANATION

LAND STATUS

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- Coal Only
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N

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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

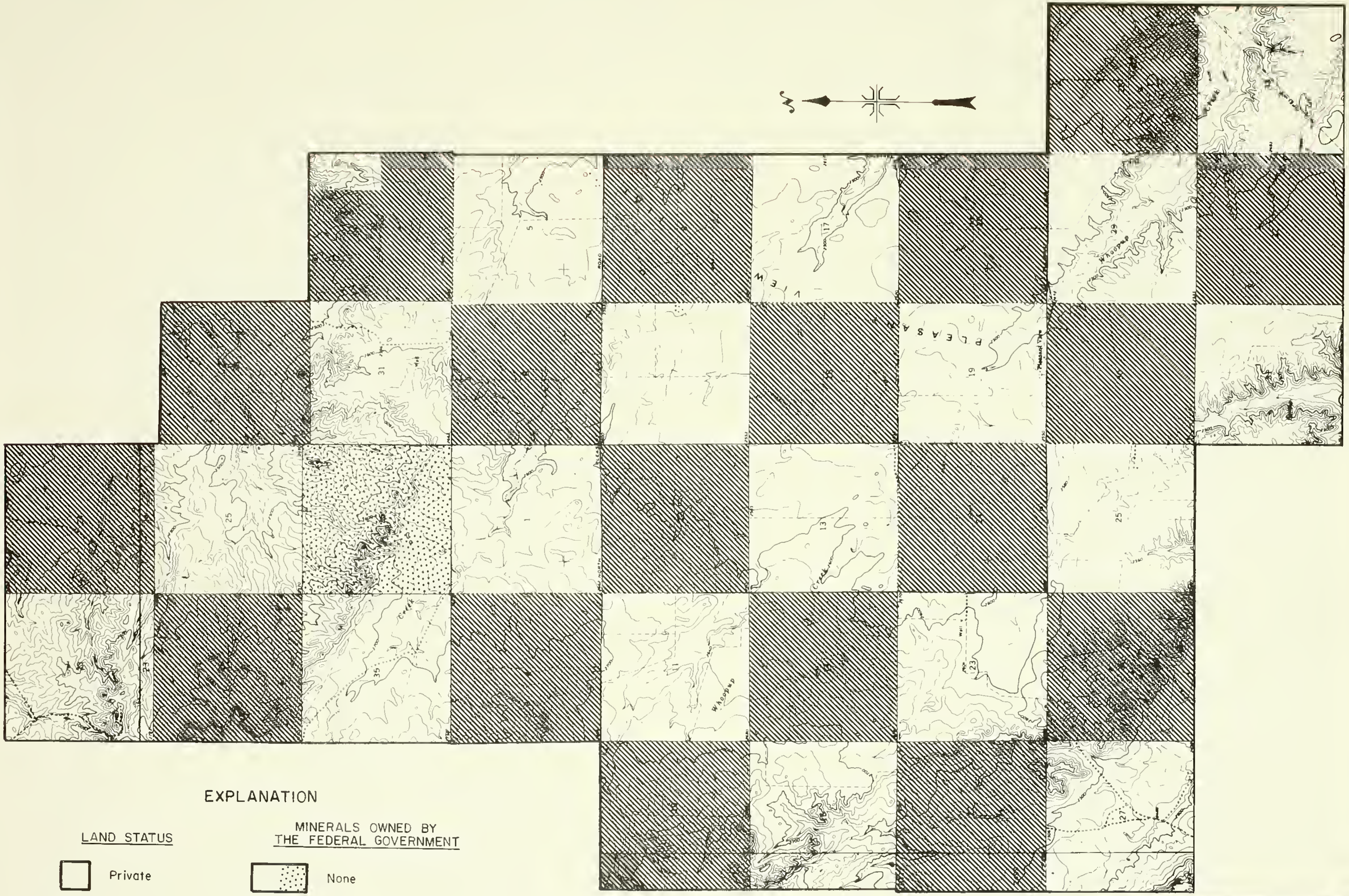
RESOURCE AND POTENTIAL RECLAMATION EVALUATION

NORTHEAST MONTANA INVESTIGATIONS
WOODSON PRLA STUDY AREA

# LAND AND MINERAL STATUS

| | |
|---|---|
| DESIGNED F. CALCAGNO | FIELD APPROVAL |
| DRAWN S. STARCEVICH | TECHNICAL APPROVAL |
| CHECKED | APPROVED |

BILLINGS, MONTANA MAY 1983 1305-600-354




EXPLANATION

LAND STATUS

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BUREAU OF RECLAMATION

RESOURCE AND POTENTIAL RECLAMATION EVALUATION

NORTHEAST MONTANA INVESTIGATIONS
SOUTHWEST GLENDIVE STUDY AREA

# LAND AND MINERAL STATUS

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BILLINGS, MONTANA MAY 1983 1305-600-355

Table 1

LAND SUITABILITY SPECIFICATIONS - SURFACE MINE RECLAMATION
Suitability of Soil/Overburden for Revegetation of Surface-Mined Areas
BLM/BR Cooperative Program
Northeast Montana Investigations

United States
Dept. of the Interior
Bureau of Reclamation
April 1981

| Soil and Overburden Characteristics | Basic Subclass | Symbols Information and Deficiencies | Class 1 | Class 2 | Class 3 |
|---|---|---|---|---|---|
| SOILS AND/OR OVERBURDEN | s | | | | |
| Textures | | | Fine sandy loams to clay loams | Sandy loam to silty clay loams | Loamy sand to clay |
| Coarse | | v | | Sandy loams sufficiently coarse to slightly reduce productivity, moisture retention and may increase erosiveness slightly. | Loamy sand in sufficient quantity to moderately reduce productivity, moisture retention, and may increase erosiveness moderately. |
| Fine | | h | | Profile should have sufficient material for topdressing, clayey type materials that are slowly permeable should be placed below 6" in the recontructed profile. | Profile should have sufficient material for topdressing; placement of clay in reconstructed profile-permeable: 10" plus; slowly permeable: 30" plus. |
| Depth | | d | >36" of soil/overburden that is suitable for plant media. | >18" of soil/overburden that is suitable for plant media. | >10" of soil/overburden that is suitable for plant media. |
| Sodicity | | a | SAR not to exceed 9.0 in fine textured materials but may be 20.0 with loamy sand textures. Values can be slightly higher if compensated by adequate residual gypsum. | | |
| Salinity (ECe x $10^3$) | | s | Less than 4. | Less than 8 but should have 10" of material of less than 4 for surface. | Less than 12 but should have 10" of material of less than 4 for surface. |
| Available Water Holding Capacity | | q | >1.5"/foot of soil. | >1.0"/foot of soil. | >0.75"/foot of soil. |
| Hydraulic Conductivity | | p | Adequate to provide a well drained and aerated root zone and an infiltration rate adequate to prevent serious erosion. | Slightly restricted which may result in some restriction of drainage and aeration in the root zone and a reduced infiltration rate. | Restricted to the extent that internal drainage may limit choice of vegetation and require special practices to control erosion. |
| Gravel (soil profile) | | k | Less than 10% by volume in soil mass. | Less than 20% by volume in soil mass. | Less than 50% by volume in soil mass. |
| Cobbly, Stony, Flaggy, or Clinkers (soil profile) | | x | Less than 5% by volume in soil mass. | Less than 10% by volume in soil mass. | Less than 20% by volume in soil mass. |
| Weatherability[1/] | | | Will break down readily upon exposure to the weather. | May require short period to break down upon exposure. | May require extended period to break down. |
| Erodibility | | | Susceptible to slight erosion. | Susceptible to moderate erosion. | Susceptible to severe erosion but can be controlled with proper management and selective placement. |
| TOPOGRAPHY[2/] | t | | | | |
| Slope | | g | Permissible surface gradient 0-12% with smooth slopes. | Permissible surface gradient 0-20%. | Permissible surface gradient 0-35%. |
| Indurated Surface Sandstone or Baked Rock | | r | None | 1 to 5% of area. | 5 to 20% of area. |
| Cover | | c | Not applicable | | |
| DRAINAGE | d | | Because of anticipated land alterations by surface mining, present drainage conditions, except the hydraulic conductivity of the material, are not a factor in the classification. | | |

Class 6

Areas delineated in this class generally lack suitable material for stripping and stockpiling as surface material. One or a combination of the following deficiencies may result in the use of this class: (1) insufficient soil or overburden of suitable quality at or near the surface; (2) topography which prevents stripping, including excessive slopes; (3) rocklands with large amounts of indurated surface sandstone or baked rock; (4) toxic material (soil or overburden), at or near the surface. Reclamation of Class 6 lands will require that suitable plant growth material be borrowed from adjacent lands that have a surplus of good quality soil material or from suitable overburden strata. In certain cases, treatment or modification of the available material may increase its revegetative potential to an acceptable level.

1/ Applicable only to overburden material.
2/ Not applicable to overburden material.

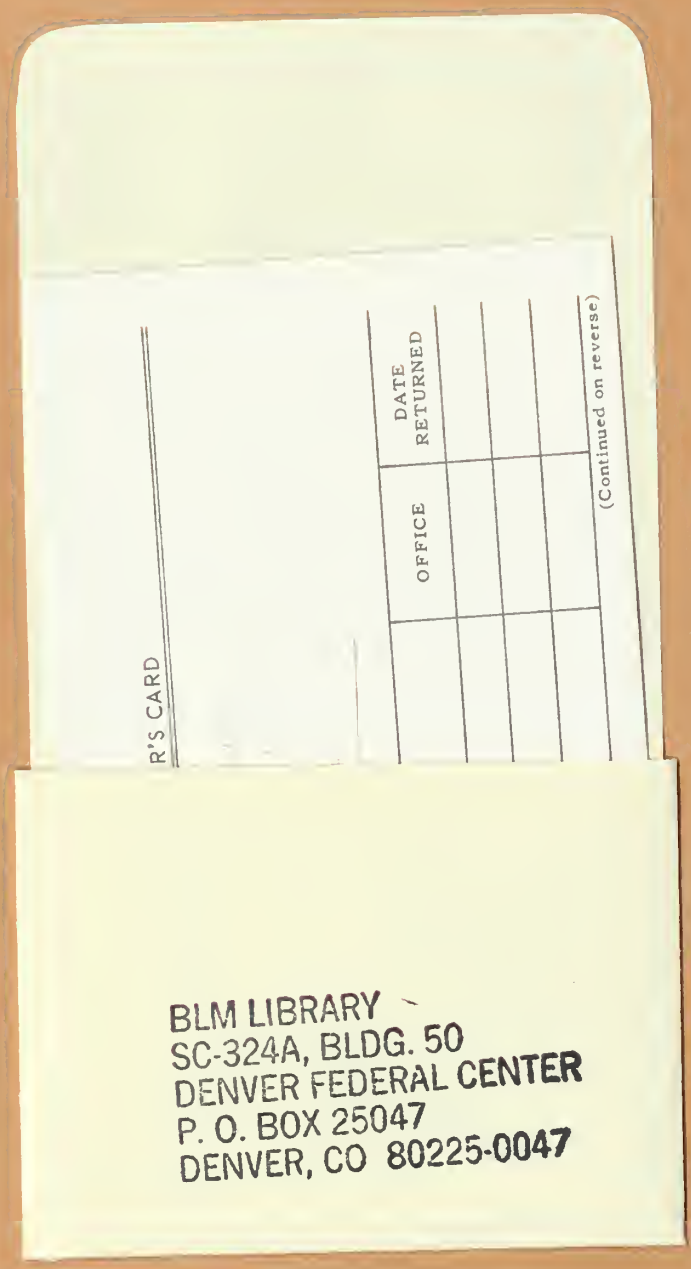
Table 2

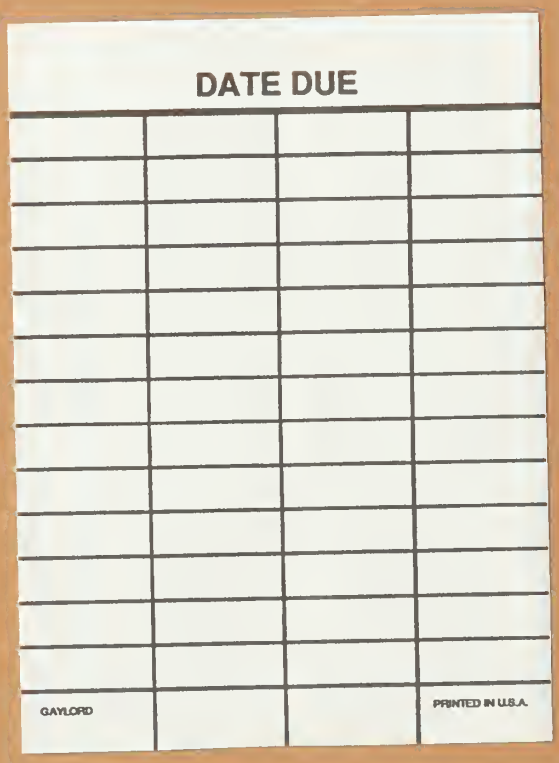
Criteria Used to Determine Suitability of Overburden Material
For Use as Plant Media in Revegetation[1/]

| Parameter | Methodology | Suitable | Limited Suitability | Unsuitable |
|---|---|---|---|---|
| Texture | Pipette method plus sand sieving | FSL, VFSL, L, SiL, SCL | LFS, SL, CL, SiCL, SC | S, LS, SiC, C |
| Electrical Conductivity (mmhos/cm) | Saturation extract/conductivity bridge | <4 | 4-12 | >12 |
| pH | Saturated paste/glass electrode | 6.0 - 8.4 | 5.0 - 6.0; 8.4 - 9.0 | <5.0; >9.0 |
| Sodium Adsorption Ratio (SAR) | Calculate: Na/ (Ca+Mg)/2; Ca, Mg, and Na in meq/l | <6 | 6-9 heavy textures 6-12 medium and coarse textures | >9 - heavy textures >12 - medium and coarse textures |
| Exchangeable Sodium Percentage (ESP) | Ammonium acetate extraction; calculate: Na/CEC x 100% | <5 | 5-15 | >15[2/] |
| Boron (mg/l) | Hot water extraction/ carmine method | <5 | | >5 |
| Selenium (mg/l) | Hydride generation; flameless AA | <2 | | >2 |
| Molybdenum (mg/l) | Ammonium oxalate extraction; flameless AA or $N_2O$ flame AA - 5000 | <1 | | >1 |
| Copper (mg/l) | DTPA extraction; AA | [3/] | | [3/] |
| Manganese (mg/l) | DTPA extraction; AA | <60 | | >60 |
| Zinc (mg/l) | DTPA extraction; AA | <40 | | >40 |
| Lead (mg/l) | DTPA extraction; AA | 10-15 (pH <6) 15-20 (pH >6) | | 15 (pH <6) 20 (pH >6) |
| Cadmium (mg/l) | DTPA extraction; AA | <1 | | >1 |
| Nickel (mg/l) | DTPA extraction; AA | 2-3 | | >3 |
| Mercury (mg/l) | Extraction by $H_2SO_4$; flameless AA (quartz cell) | <0.5 | | >0.5 |
| Iron (mg/l) | - | | Not Established | |
| Nitrate-Nitrogen (mg/l) | - | | Not Established | |

1/ Applicable only to reclamation study areas in Montana and North Dakota.
2/ Rate 2:1 - Clay texture poor if >10, sand texture if >20.
3/ Suspect level not established - an excessive consumption of molybdenum through ingestation of vegetation may be toxic to animals. This concern is directly related to the Cu:Mo ratio in the plant tissue.

GPO 640-219

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